Ex Tridenti Mercatus? Sea-power and Maritime Trade in the Age of Globalization

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Abstract

This paper tests an implication of the hypothesis that hegemons provide increased global stability and thus promote international commerce. Specifically, we measure the influence of naval power projections on global trade during the latter 19th and early 20th centuries, a time of relative peace and robust commercial activity. We use archival data on the navies of Britain, France, the United States and Germany, capturing longitudinal measures of ship deployment, tonnage, and ship personnel. First we develop an empirical naval arms race model, and demonstrate that the navies of Britain and France in particular responded rigorously to each other. We then use our estimates of naval power projected around the world by Britain and France to measure their effects on bilateral trade in a panel-data gravity model. Results indicate that while navies had some positive impact on their own nation's trade, other nations' trade suffered. Our results show that rather than bolster globalization, the first global arms race damaged commercial interests and lowered trade potential around the world.

- *Keywords*: trade, arms race, 19th century, war, mercantilism, naval power
- *JEL Codes*: F1, F5, N4, N7

1 Introduction

"Without commerce the navy would not be needed; without a navy commerce could not exist." — Commodore George M. Ransom, USN.[1]

The late 19th century witnessed an unprecedented rise in international commerce (O'Rourke and J.Williamson 2002). Economic historians still grasp at the reasons for this wave of globalization — was it due to transport technologies (Harley 1988), the gold standard (Lopez-Cordova and Meissner 2003), or shifts in the international system of trade (Irwin and O'Rourke 2011)? But the rise of military power and its influence over global commerce remains under-explored, particularly for this crucial period for the histories of world trade and military expansions. Did the rise of a few hegemonic powers and the rapidly growing use of the tools necessary for the expansion of power affect trade?

Our study uses archival naval data to assess how sea power projection from the major powers affected bilateral trade patterns from the early 1870s until the precipice of the Great War. Outright wars can disrupt trade through a variety of channels, through embargoes, or privateering activities, or the fomenting of market uncertainty (J.Williamson 2011). Naval vessels can conceivably either strengthen or hinder such forces. While the trade-stimulating peace of the *Pax Britannica* prevailed, naval powers still exerted great influence over trade patterns.

To our knowledge the only other empirical study on the effects of naval power on commerce is Rahman (2010), which establishes a general link between naval power and trade for the 18th, 19th and early 20th centuries. Specifically, fighting war ships tended to lower world trade, even for neutral countries, while neutral ships tended to increase world trade. These naval effects are both statistically significant and economically meaningful. The weakness of Rahman (2010) is in its reliance on aggregate measures of sea power-projection. These aggregate measures do not distinguish between ship activities, nor the location of ship deployments. To estimate the trade impacts of active vessel deployment *to a specific region*, such distinctions are crucial.

Incorporating these distinctions into our current study facilitates a test of a particular aspect of

[1] from "The Naval Policy of the United States," *United Service 2*, 1880.

the Kindleberger Hypothesis, which states that hegemonic powers produce public goods that can generate positive spillovers such as peace and commercial security (Kindleberger 1973, 1981).[2] Others have echoed this idea when observing naval power struggles during the "long" 18th Century (Modelski and Thompson 1988), and the U.S.'s seeming displacement of Britain as the "globocop" of the 20th century (Ferguson 2006). An alternative view exists which might be described as "neo-mercantilism," where one hegemon's commercial security must come at the expense of another's (Bartlett 2011). It is a conceit anticipated by Parliament member Richard Cobden when he warned in 1846 on empire building's disruptive effects on free trade.[3]

To test these competing ideas we analyze naval power projection and its effects on world commerce. This approach allows us to capture the effects of *de facto* measures of power projection, as opposed to effects from *de jure* changes in international policy by hegemons. Specifically we construct naval power metrics which vary by country of origin, region of deployment, and time. To these measures we link bilateral trade data (which varies by country-pair and year) and other various control variables. We analyze not only how ships stationed in a region affect trade between regions, but also different effects on a naval power's own trade as well as *other* countries' trade. The distinction is important, as a navy's effect on commerce may be considered a private good for the naval power, but a public good (or bad) for others. That sea-power has been used as a national defense strategy to protect one's own trade and commercial interests is uncontroversial.[4] Our study differs, however, by demonstrating how naval power can additionally create international externalities that either help or harm the trade of other nations.

This paper joins the body of literature that has analyzed how military presence affects trade. One branch of analysis considers the effects of international conflict on trade.[5] Another branch of research analyzes the transport infrastructure of trade (Irwin and O'Rourke 2011), of which sea-going navies form an important component. Our study combines aspects of both. Furthermore,

[2]The specific idea is labeled "Hegemonic Stability Theory."

[3]Speeches on Questions of Public Policy. Vol. 1 Free Trade and Finance (Richard Cobden).

[4]See for example Lewis (1959), Crowhurst, (1977), Harding (1999).

[5]Results from this body of work are mixed. Bergeijk (1994), Mansfield and Bronson (1997) and Glick and Taylor (2010) estimate gravity models and find that conflict lowers trade; Mansfield and Pevehouse (2000) and Penubarti and Ward (2000) also estimate gravity models but find no statistically significant effects of conflict on trade.

the period we analyze is ideally suited to understand the effects of naval *hegemons* on commerce. The primary hegemonic tools of power projection during this period were heavy cruisers and battleships, overt pieces of very expensive capital that contained more destructive power than anything that beforehand existed. After the Great War, naval power expressed itself more stealthily in the form of submarines and grew far more difficult to quantify, particularly with respect to locations of deployment.

Capturing the *causal* effects of naval power projection on trade however is complicated by the fact that naval deployment is in part motivated by concerns over trade.[6] During this period navies were considered by some to be "pioneers of commerce."[7] How navies responded to trade flows remains unclear; naval powers could protect their own trade but could also disrupt or siphon off the trade of rival powers. To address this endogeneity, we employ a two-stage strategy. First, we develop an empirical model of naval power projection, where countries deploy naval capital to different regions for many motivations, including responses to naval deployments by rivals. Thus, our first stage is a simultaneous equations model, where naval deployments to certain regions at certain times are *jointly* determined by all major naval powers. We identify this system using a number of country-specific variables related to each nation's unique naval capacity and strategic concerns. We argue that these variables are orthogonal both to the naval deployment of a rival power in a particular region, and (more importantly) to bilateral trade flowing through particular regions. This "arms race" model produces estimated measures of naval power deployments around the world.[8]

In the second stage, we incorporate these estimates in a gravity trade model. Following Glick and Rose (2002) we construct a gravity model with panel data using country-pair fixed effects estimation to control for any time-invariant country-pair characteristics.[9] The naval power estimates created in the first stage mentioned above instrument for spillover effects of power

[6]As we demonstrate in the results, Hausman tests for endogeneity suggest its presence.

[7]Schufeldt, Robert W. 1878. *The Relation of the Navy to the Commerce of the United States — A Letter Written by Request to Hon. Leopold Morse, M.C., Member of Naval Committee, House of Representatives.* J.L. Ginck.

[8]See Blalock (1985) for an in-depth discussion of use of simultaneous equations in modeling arms races.

[9]We also estimate these using OLS, random-effects, and exporter-importer fixed effects, all producing similar results. We illustrate results from using exporter-importer fixed effects in the Appendix.

projection on commerce. Arguably they influence trade between two particular countries but are themselves not influenced by such trade. Concentrating attention on the spillover effects of navies provides us another view of the causal effects of military expenditures on international trade.

We first compile data on vessels from the printed naval registries of four major powers of the time: Britain, France, Germany and the United States. These registry books, housed in the archives of the United States Naval Academy and arranged in annual volumes include lists of active naval vessels, their stations of duty (i.e. locations of regional deployment), and basic ship characteristics such as rate, number of personnel, and displacement (in tonnage).

To this we merge a number of other data series (discussed in section 4). The final merged dataset can gauge the global effects of military power while evolving both spatially and longitudinally. Each country-pair year observation includes estimated measures of naval power. These are aggregate measures of naval power active in waters through which commerce between two nations could conceivably flow. While studied and discussed extensively by naval historians, this rich data on naval vessel deployment has hitherto never been codified, and thus has never been used in careful cliometric study.

Our results, robust to numerous empirical tactics, provide a number of insights. With our first stage "arms-race" study, we see that the British and French compete primarily with each other, matching each other's naval deployments. Perhaps unsurprisingly, the United States does not appear to impact this race in any straight-forward way. We also observe that the French are increasingly replaced by Germany as Britain's primary rival, and the arms race shifts concentration over time into northern European seas. Naval strategy was motivated by other factors as well. Global forces such as Britain tend to deploy more naval resources to international "hot-spots" where tensions erupt between it and a country in the region. These empirical results appear consistent with the rhetoric of prevailing naval strategies among the global powers: Britain's *Bluewater School*, France's *Jeune Ecole*, and America's Mahanian doctrine.

Using estimates generated from this exercise in the gravity model, we discover that the two most important naval powers at the time (Britain and France) promoted their own respective trade by protecting their commercial interests and/or enhancing their trading networks. But contrary to the idea of navies producing commerce-enhancing peace dividends globally, these powers dramatically lowered the trade of other countries. The bulk of our evidence suggests that the first global arms race fostered neo-mercantalistic effects of trade enhancement within the empire blocks of France and the United Kingdom, while choking off trade for those outside these blocks. And of course all these developments helped to erect a naval infrastructure responsible for commerce destruction on a much grander scale after events ignited in 1914.

Our findings suggest that British-led "globalization through gunboats," such as described by Ferguson (2003), runs into two limitations. Understanding these can help inform more contemporary American-led globalization through gunboats. The first of these relates to arms races. Those who gaze doe-eyed at the developmental powers of British institutions and culture (her language, her Common Law, her bridled government) should realize that their exportation through naval projection promoted projection from rivals, with their own institutions and culture. That is, spreading the "British way" through ships promoted a counter response for ships freighted with more Gallic traditions. The second limitation relates to explicit trade effects. Navies serve as mercantalist tools wielded during a supposedly non-mercantalist period. Current proponents of freer trade through American-led efforts should take some note.

It also bears noting that we test only one facet of hegemonic stability theory during one period. We do not suggest from this that naval powers could not foster calm and harmony around the world in other respects, such as through international relations. Nor do we imply that navies could alone promote global stability.

The rest of the paper is organized as follows. Section 2 provides some historical background. Section 3 explains the first stage arms race model, and section 4 explains results from the gravity model.

2 Background

2.1 Projections of Sea Power...

In the second half of the nineteenth century tensions between states found a new expression through a race of arms. The mid-nineteenth century *naval* race between Britain and France was in fact the first example of an arms rivalry between what we would characterize as technologically modern societies. The race was particularly fierce in the latter 19th century, despite (or perhaps due to) the extended peace of the *Pax Britannica*. The race effectively ended in 1912 when the exchange of the Grey-Cambon letters ushered a new era of naval cooperation between Britain and France (S.Williamson 1969). Up to that point however an enormous global naval infrastructure had been erected. The Britain-France arms race had contributed more than any other factor to the emergence of the modern battleship, "the most complicated machine of the nineteenth century" (Hobson 2002), and the primary mode of naval power projection of the time (Modelski and Thompson 1988).

Many underlying factors motivated the surge in naval projection by Western nations. Among these was a desire for empire-building. The alleged necessity of expansion was fuelled by the need to stem the rise of competing empires, to control markets and sources of raw materials, and to control 'inferior races' by running their affairs. The naval powers, although nominally at peace with each other, engaged in a 'silent war of steel and gold', developing their naval programs and using all industrial and financial resources they could muster (Ropp 1987). Enthusiasm for potential *future* war spurred much of this naval build-up (Glaeser 2009).

This paper attempts to determine how mercantilistic were the outcomes of this naval race. The race happened for many political and strategic reasons unrelated to trade, which shapes our empirical study in the next section. Certainly navies were used to protect and open markets, but peacetime navies also policed international waters, improved the safety of navigation, enforced neutral rights, attempted to expand scientific knowledge, and generally protected sovereign interests (Bartlett 2011). New overseas bases were sought not necessarily for their intrinsic economic value, but as potential stepping stones to more important places. Indeed existential threats at times appeared manufactured to spur greater naval expenditure (Glaeser 2009). With industrialization, naval power increasingly became an *offensive* weapon by which hegemons could exert pressure on modern industrial nations (Kennedy 1991).

Throughout this period Britain led the race, keeping well ahead of its closest rivals by spending around £5M annually through the end of the 19th century.[10] Part of its goal was to persuade its

[10]Source: http://www.cityofart.net/bship/gunnery.html

primary rival France that they could never win a naval competition with them. Not only did this not have the expected effect on France, it helped spur the 1898 Navy Law committing Germany to building a new navy to directly compete against the Royal Navy (Hobson 2002).

During this time British defense strategy, the so-called *Bluewater School*, emphasized dominant command of the sea (see figures 1–2 for some sense of this domination as measured by active sea power). The necessary precondition of such superiority placed British vessels near foreign ports, deemed the most cost-effective way for Britain to defend her hegemony. To accomplish this, legislation including the Naval Defense Act and the Spencer Program initiated a massive naval buildup.[11]

As for France, the end of the Franco-Prussian War in 1870 and the peace terms that followed stripped the nation of territory and imposed a huge indemnity on the country. This helped give rise to vengeful groups within the military, arguably spurring a more muscular military stance (Hobson 2002). A great contingent of the French populace also pushed for imperialism, emphasizing its importance for the continuation of France as a great power. Above all they obsessed over the development of an effective strategy against Britain and the struggle for colonial territories and markets.

At the birth of the Third Republic, French naval strategists grappled with questions concerning the type of navy they should build. What could their navy achieve, given Britain's clear domination of the seas? The French Admiral Baron Grivel suggested that a maritime power of secondary stature should engage in commercial warfare against stronger opponents and traditional squadron warfare against weaker ones. This indicates how France's naval strategy would appear quite distinctive from Britain's; part of our empirical results in this paper test this hypothesis.

What about other naval powers? The navies of Britain and France had vital roles to play in promoting national defense, and they relied on centuries of experience with naval warfare. By

[11] The Naval Defense Act established the standard for Britain to maintain its number of battleships to be at least as many as those from the next two largest navies (which at that point were France and Russia). This greatly contributed to the arms race, though of course the original objective was to prevent the race in the first place. The Spencer Program was another expansion aimed to match foreign naval growth. It bears mentioning that after 1889, when the Naval Defense Act was enacted, British spending was much above the minimal spending stipulation for the entire period under study.

contrast, the United States and Germany had much younger navies, with more marginal roles for national defense and less history and experience on which to rely (Hobson 2002). The United States in particular was not regarded as a serious challenger to Britain during most of this period (Sprout and Sprout 1943).

Yet while the U.S. had a much smaller fleet, its strategy slowly evolved into one similar to that of Britain's. Starting modestly in the 1870s, the U.S. began its naval buildup in earnest in 1883, and by 1890 the modernization program greatly accelerated. At the initiation of the program the U.S. Navy ranked 12th among the powers; by 1900 it had advanced to third place (McBride 2000).[12]

Germany also began to expand naval power in the 1890s. Kaiser William envisioned a grand internationalist and expanding future for Germany. To the dismay of the British, the Kaiser's policy called for a navy equal to that of Britain. Soon thereafter the British and the Germans began "programs of vilification," suggesting existential threats from the other power and fuelling the naval arms race (Glaeser 2009).

2.2 ...and Their Effects on Commerce

This paper suggests that the arms race had important effects on inter-continental trade, both in positive and negative ways. The flexing of military might involved economic costs and benefits for both hegemonic powers and the entire world. Their net effects in history should be more fully explored to understand the potential economic consequences of military exploits today (Findlay and O'Rourke 2008).[13] That navies can potentially provide a public good such as commerce security has been suggested before (Irwin and O'Rourke 2011). Trade was often diverted for security reasons, motivated mainly by the naval power that had primary control over main

[12]Much of this expansion can be attributed to Alfred Mahan, whose naval doctrine, arguably adapted from the British, might be called a "theory of mercantilistic imperialism" (Gough 1991). The naval expansion he championed was tightly linked to his unwavering support for overseas territorial and economic expansion. It was Mahan who introduced to the U.S. the idea of naval use during peacetime to generate economic benefits from command of the sea, an idea long championed in Britain.

[13]China's recent expansion of naval power particularly in the South China Sea and the countering naval responses by the United States in the name of "trade facilitation" underscores the repeating and current relevance of this discussion.

shipping lanes (Taylor 2003). The Royal Navy in particular had strong interests in securing the oceans and sea lanes for trade, given that Britain was becoming a large net importer of food (Irwin and O'Rourke 2011). Britain's leading naval strategist in 1877 summed it up nicely: "In 1813, the British people lived on the produce of their soil. In 1875, that people required side by side with every pound's worth of raw cotton for manufacture, one pound's worth of raw corn or flour for their sustenance" (Colomb 1877).

Naval leadership in Britain certainly recognized the rising importance of *their* commerce and the need to protect it. Naval power could in fact be used to covertly promote trade policy.[14] Captain J.R. Colomb of the Royal Marines laid the foundations of the *Bluewater School* in 1867 by ranking British naval priorities as: first to defend Great Britain and Ireland, second to protect British commerce, and third to occupy India. Concerning the second point, he stated that "it is beyond dispute that the general welfare of the Empire depends chiefly upon its commercial prosperity, and therefore we conceive that our regular forces abroad should be distributed in time of peace in such a manner as would best secure protection to our commerce in the event of sudden war" (Colomb 1867). He envisioned the navy affording British merchant protection not merely to the English Channel (although that of course was a prime necessity) but also to the main trading routes around the world.

Such a philosophy also held that lasting peace through naval influence could promote prosperity and trade performance (Mitchener and Weidenmier 2005). To protect trading routes, British ships were spread far and wide. Many believed this form of "global leadership" served as a stabilizing force that lasted up to 1913 (Kindleberger 1973).

France and the United States (once the latter shed their post-bellum isolationism) also purported to use their navies to facilitate overseas commerce. Though not as dependent on foreign trade as Great Britain, both countries' regional hegemony was sensitive to global finance (Mitchener and Weidenmier 2005). The U.S. in particular often used its naval powers for commercial missions.[15]

[14]For example naval power allows countries to forsake standard tarriff and subsidy instruments, much like the 17th century powers were able to use their monopolistic trading companies to promote mercantilistic aims (Irwin 1991).

[15]The most famous example might be when it sent one-fourth of its Navy in 1853 to open Japan to American

Yet the *overall* global commercial effects remain unknown, in part because there are many potential factors where naval powers can *lower* trade flows around the world. During the early 19th century both British and French navies regularly seized American cargo and ships (Irwin 2005). As industrialization became increasingly fuelled by international commerce, sea power rose in importance for economic and industrial strategy. Naval strategists recognized that countries like Great Britain and Germany had become perilously dependent on imports of foodstuffs (Offer 1989).

Maritime commerce was thus vulnerable to aggressive navies, and the opportunities for such disruption expanded rapidly as trade around the world grew (Ropp 1971). A total command of the sea was not required for this sort of tacit commerce warfare; the primary objective of France's *Jeune Ecole* for example was to use its naval power to economically disrupt its rivals, in part by raising insurance rates that would subsequently lead to higher prices for food and raw materials (Hobson 2002). Merchants and sailors would in turn demand higher compensation for *ex ante* threats to their voyages (Hilt 2006).

Perhaps more importantly for this period, naval expansion had the potential to divert trade from rival or non-naval powers to the hegemon. For all its genuine beliefs in the merits of free trade, the British Empire maintained a fairly tight trading-bloc — its navy could have very well strengthened this bloc by helping divert third-party trade to the Empire (Jane 1997). This neo-mercantalistic use of naval power offers a counter-perspective to the more sanguine viewpoint of naval power implied by hegemonic stability theory.

Thus whether naval power helped or hurt maritime commerce appears to be an open and empirical question. We go beyond the rhetoric of the trade and peace "dividends" of navies and empirically explore the effects of naval power on commerce in the next sections.

traders (Morck and Nakamura 2007). Also, the U.S. intervention in Santo Domingo made credible the threat of naval forces conducting gunboat diplomacy or seizing foreign customs houses in Central and Latin America to promote trade (Mitchener and Weidenmier 2005). And when American naval forces were sent to the Philippines to wage war in 1898, Philippine merchants urged the U.S. to take control of the Philippines in the belief that this would boost business (Rockoff 2012).

3 Estimating Measures of Naval Power Projection — An Empirical "Arms-Race" Model

From the history of 19th century naval power, we see that naval expansion by hegemons likely had profound trade impacts. But testing the actual impact of naval deployment is complicated since it motivated, at least in part, from concerns over commerce. We tackle this problem in two stages.

For the first stage, we develop an empirical model of a naval arms-race by estimating a simultaneous equations model (SEM) of the naval deployments for Great Britain, France and the United Staes. Specifically, let z_{cst} be a measure of naval power deployed by country c in region (station) s in year t. These will be measures of gross ship tonnage of vessels deployed to region s, or alternatively measures of total ship personnel. Our empirical specification for naval power c is:

$$z_{cst} = \beta_0 + \sum_{l \neq c}^{L} \beta_l z_{lst} + \sum_{m=1}^{M} \gamma_{cm} x_{cmst} + \varepsilon_{cst} \tag{1}$$

for $c = \{\text{Britain, France, U.S.}\}$, and $l = \{\text{Britain, France, U.S.}\}$. Thus naval deployment by a naval power to region s will be a function of the deployments to the same region of the other L navies being considered, and of M exogenous factors (x) which influence the deployment of vessels by the naval power. As we typically consider three navies, L will either be one (c is either Britain or France) or two (c is Britain, France or the U.S.).[16]

These power projections may be jointly determined. Since the structural errors ε_{uk}, ε_{frn}, and ε_{us} may be correlated with each other, we also estimate this system using simultaneous equations. This requires an IV/2SLS approach, where we initially regress country c's naval projection on all exogenous variables (x_c), produce predicted values for z_c, and then estimate (1) using our predicted measures of the naval deployments of rival naval powers. The resulting final estimates will then be used as exogenous variables in our gravity trade model.

[16]Because data for the German Navy is mostly limited to the 20th century, we typically either exclude it, or include it as the rival to Britain for the 20th century and substitute the French Navy as Britain's rival for the 19th century.

To estimate (1), we require measures of power projection, and measures of exogenous variables which influence these projections. By "naval projection," we mean the extent to which navies deploy forces to specific regions. Because we have data on the ships stationed abroad for each naval power, we can construct such metrics. For power projection measures, we alternatively use total ship tonnage (displacement) and total number of officer personnel aboard vessels. We also use measures of "technologically-weighted" displacement to capture technological differences embedded in naval capital.

We use original-source data for four naval powers. These include the number of ships deployed, tonnage, and personnel aboard each vessel for Great Britain (1878–1914), France (1872–1913), the United States (1870–1911), and Germany (1891–95, 1901–1910).[17][18] Table 1 provides some summary figures for these data.

All observations are for active vessels only. Observations are at the region(station)-year level (s, t). Regions are the North Atlantic, South Atlantic, Eastern Pacific, South Pacific, North Sea (Europe), the Mediterranean, the Asiatic front, and the Indian Ocean. One potential complication is that each navy may define station locations in slightly different ways, with some powers reporting with greater precision than others. After careful consideration of all reported details, we limit the number of stations to these eight that have the most overlap across navies, and suggest that some navies had no real presence in certain stations (see figures 3–6 for ship location by station). Of course it would be potentially problematic if our core results hinged on one particular choice. So we try a myriad of sensible alternative station set-ups.[19] Results of these are not reported here (available upon request) but demonstrate great consistency in our findings for both stages of analysis.

[17] The gaps in coverage are for full years (certain annual volumes of navy registries were unavailable). For years that are covered, the data coverage is comprehensive and complete — we capture every active vessel, where it is deployed, and basic ship characteristics.

[18] Due to lack of consistent data for Germany, we do not explicitly *estimate* German naval deployment, but rather use observed German naval deployment as a potential explanatory variable for potential rival naval deployment.

[19] An example would be where we combine the North Atlantic and North Sea as one station. Another would be where we combine the Eastern Pacific and Asiatic stations.

3.1 Identification Strategy

Estimating the simultaneous system of equations requires having exogenous variables that influence naval power c's deployment of vessels and personnel to a region. To properly "instrument," we interact exogenous variation in the country's *capacity* to deploy vessels (varying over time), and the distance of the stations to where vessels are sent (varying over space). What constitutes a proper measure of capacity? Below we display results for when we use naval expenditures; these measures aggregate spending on nearly all areas of naval operations, denominated in 1913 British pounds. This variable strikes the proper balance between a strong correlation with a country's ability to deploy vessels, and a lack of direct relation to any trade flows in any particular area.

Much historical evidence supports the claim for exclusion restriction. Hagen (1991) demonstrates how the myriad of random international and domestic events influenced naval budgets, including local economic fluctuations.[20] Schulman (1995) goes further, showing for the U.S. case that domestic factors such as political and cultural changes primarily lead to new naval policies during this period. Sexton (1976) carefully analyzes Congressional voting records, suggesting that changes in congressional representation had profound influences in expenditures as naval appropriation bills passed or failed nearly completely on party-line votes. Indeed few in government really understood the broad strategic implications of their votes, let alone how naval expenditures would influence deployments to particular regions around the world (Sprout and Sprout 1939). Use of expenditures in the first stage suggests that these expenditures do not directly influence trade between any two countries.

Further, we use a number of alternative measures of naval capacity to produce alternative naval power estimates. These include aggregate total military expenditures, taken from the Correlates of War's National Materials Capabilities dataset (Singer et. al 1972). We also use lagged naval expenditure variables (either individual-year lags or a fuller set of lagged terms). Finally, we construct lagged measures of repairing vessels being readied for deployment, and naval

[20]For the case of Britain, the debate over the extent to which naval expenses should be shared among the members of the British Empire was hotly contested, resulting in many fluctuations stemming from diplomatic factors (Davis and Huttenback 1986). For all powers involved, the balancing between security and fiscal needs in budget appropriations were debated with passion.

personnel working on repairing vessels.[21] All these are likewise correlated with ship deployment and arguably satisfy the exclusion restriction. The resulting effects on trade (results not reported) when using these alternative instruments closely mirror those presented here.[22]

We also use a naval expenditure-distance cross term to gauge how random naval budget allocations interacted with deployment to particular regions. Along with these we use a number of other explanatory variables that relate to conflict between the naval power and a country in the region.[23] Such conflicts should not *directly* influence trade between two nations whose merchandise happens to pass through nearby waters; rather naval powers may influence commerce *indirectly* as they arrive in these regions. Further, as each navy had rather different strategies regarding its role in policing international waters, disruptions occurring in different places in the world would potentially have different naval responses. We also use information on the number of allies that country c has located in region s, to gauge how allegiances might influences naval deployments.

Finally, we use naval deployments by the United States and Germany in the simultaneous equations model to further motivate deployments by Britain and France. Because our focus on naval trade effects will be for these two global powers, using the naval projections of *other* navies provide us further exogenous variation to determine the causal effects of deployment on trade.

As we use estimates from this first stage in our second-stage gravity model, we also argue that we have enough first stage power to perform the analysis. As described below, a number of factors suggest the analysis does not suffer from weak instruments.

These first-stage exercises accomplish a number of things. They provide a new quantitative assessment of the first "arms-race" among hegemonic powers in modern history. They allow us, in an empirically robust way, to observe who "competed" against whom. More critical to the overall objective of this paper, they produce estimates of the causal effects of naval power projections on world trade.

[21]The latter measure is only available for Britain.

[22]We also include a time trend in these specifications. The estimated effects of expenditures on naval deployment remain unaffected with this inclusion, and estimated coefficients on time trends are statistically insignificant in all specifications.

[23]Conflict and alliance data are taken from the Correlates of War Database.

3.2 Empirical Findings

Tables 2–4 below demonstrate our results for the first stage of our empirical exercises. In all cases the top variables show factors which conceivably influence naval power projection in exogenous ways, while the bottom variables are measures of similarly measured naval deployment by potential rivals.

We begin with Britain. Table 2 shows the empirical results when we use the gross tonnage of British vessels in a station as the dependent variable. We consider France and the United States as potential naval rivals, although we also consider Germany by constructing a hybrid France-German naval deployment variable in the last specification.[24]

As we will see for the results for all naval powers, naval expenditures (varying only over time) are positively related to power projection, while the expenditure-distance cross terms are negatively related to power projection. Both of these make sense (higher naval spending creates greater ability to send out ships, but naval funding takes more time to materialize as ships in more distant waters), and these serve as a major source of exogenous variation.[25]

As we discuss in the prior section, naval spending serves as a valid instrument here for a number of reasons. It seems clear that the many vagaries of legislation and budgeting divorced actual naval expenditures from any specific commercial interests for all the major naval players considered here. Further, as is clear from the expenditure-distance cross term, there is a natural and considerable lag between when funds are spent and when they appear in the form of a ship in international waters.

We also see in the first specification that all navies tend to send vessels out to regions where there is some hostility between it and another country in the region. This also makes a great deal of sense. We thus control for regional hostilities in both stages. Again, the idea here is that local hostilities should not directly influence trade between two countries by sea (given that most regions are extremely large), but might indirectly do so since they attract naval vessels which

[24]After 1900, the rivalry between Britain and France became more strategic as growing German power encouraged them to overcome their ancient rivalry and establish the *Entente Cordiale* (MacMillan 2013). So for this variable we use French naval deployment prior to 1900 and German naval deployment after.

[25]Effects of distance alone will depend on both degree of geographic isolation and international ambition of each naval power.

have much greater geographic reach.

In specifications 2–6 we include potential rival naval power projection. The positive association between British and French power projections suggests the use of simultaneous equations. In general, the British is highly responsive to French deployment — for every ton the French send out, the British respond with 50 to 100 percent more tonnage. When we include Germany (in specification 6), we can say that Britain appears to at least double its naval force relative to its main naval rival.[26]

We also perform the same analysis but use alternative measures of naval deployment — total number of officers serving aboard active vessels, and "technologically-weighted" measures of displacement. All results (not displayed) echo the results presented in tables for displacement.

Table 3 performs the same exercises, but now consider the naval deployments of France. We observe similar qualitative effects from expenditures and distance-expenditure cross terms. We also see that the French likewise respond to British deployment. But of course they can't keep up with the British, either in terms of tonnage or technology. Specifically, the French are able to match roughly a third of the naval power of Britain when it comes to tonnage.

Estimates here represent the first quantitative evidence of the first ever truly global arms race. The race was not just confined to Europe but also reached many distant regions, having the potential to shape world commerce in profound ways.

Finally we look at the determinants of U.S. naval deployment. Table 4 displays the results. While the U.S. Navy appears to respond to similar "stimuli" as its peers (spending is positively related, spending-distance cross-term is negatively related, and hostilities with U.S. are positively related), it does not engage in the naval arms race with Britain or France in any straight-forward way (seeming to steam to similar regions as the British but also seeming to avoid the French). This also conforms to history, as the United States was not a true global power during this time.

[26] Note that the inclusion of German naval power in the 20th century greatly weakens the statistical significance on estimates for naval expenditures and expenditure-distance cross terms for Britain and France. This is likely due to both powers shifting naval forces locally as Germany began its naval around the North Sea. Inclusion of German naval power projection as an additional "instrument" will not affect our estimates on British or French naval power on trade.

4 Effects of Naval Power Projection on Bilateral Trade

We now want to see how the naval arms-race among the super-powers of the late 19th century affected global commerce, both for the hegemonic powers and for other "third-party" countries. To that end we use the estimates from our previous exercise in a panel gravity model, the workhorse of empirical trade literature. That is, we use predicted measures of naval projection (alternatively using gross vessel tonnage and total number of naval officers) as separate explanatory variables in our gravity model. We use these measures to consider the extent to which naval power helped that nation's trade, and the potential *spillover* effects from naval power on third-party trade.

A measure of naval power projection is given by the following dot product:

$$power_{ijct} = \widehat{navy}'_{cst} \cdot s_{ij} \tag{2}$$

Here $\widehat{navy}_{cst}$ is a 1-by-N vector of naval power projection measures for naval power c at time t across N different regions. s_{ij} is a 1-by-N *spatial* vector, comprised of ones and zeros denoting the relevant regions through which conceivably maritime trade between countries i and j would pass.[27] In producing our power measures, we generally use *predicted* values of $navy_{cst}$ that we produce from the above exercises — specifically we use either the spending and geographic components of power estimated by OLS regression (call this the "2-Stage Model"), or the spending, geographic and arms-race components of power estimated by (1), which *simultaneously* estimates power projection by Britain, France and the United States (call this the "3-Stage Model" since SEM estimation itself requires 2 stages).[28] [29]

[27]Once again, there are eight possibilities — the North and South Atlantic, the East and South Pacific, the North Sea, the Mediterranean, the Asiatic front, and the Indian Ocean.

[28]Note that the data used to estimate the system of equations described in (1) vary by station and year, while data used to estimate the gravity model vary by country-pair and year.

[29]Note that for the 2-Stage Model estimates, we use the first specification from tables 2 and 3. For our 3-Stage Model estimates which employ simultaneous equations, we use the fifth specification from tables 2 and 3. Alternatively, we use only conflict and alliance information to estimate naval power projection, or only naval spending and distance information, and use these estimates in the bilateral trade model. These alternative ways of estimation does not alter our findings on the effects of naval power on trade, suggesting we do not suffer a weak instrument problem due to multiple instruments. Finally, we can also include German naval power after 1900 in the 3-Stage Model. Bilateral trade effects do not change with this adjustment.

We use *estimated* values of naval power, as opposed to only directly observed values, for several reasons. The first is simultaneity — trade between countries might motivate hegemons to send naval capital to certain regions. We want to use variations in naval deployment not directly related to bilateral trade.[30] The second reason is potential omitted variable bias — if naval deployment by one power is heavily influenced by the deployment of a rival power (as appears to be the case for Britain and France), then the measure for any single naval power will be correlated with the error term. By using naval power estimates from the simultaneous equation model, we gauge the potential trade effects from each naval power in isolation.

We have two alternative series of spatial vectors (s's). The first considers any region through which trade between countries i and j would pass as fair game (takes on a value of 1). The second considers only the regions where i and j are located — it thus ignores in-between regions, and so considers two regions at most. Results below are only for the first case, but results for the second echo these quite closely (not reported but available upon request). For all cases, we allow all countries to access the Suez Canal, and assume they do so if it results in the shortest maritime trade route. Along with other assumptions, we assume that Euro-Asian and Afro-Asian trade must traverse the Indian Ocean, and trade between the Americas and Asia must traverse the Pacific Ocean. We do not consider the trade of countries which share a border here.[31]

In terms of trade data, it is assembled from two main sources: Barbieri (1996) and Mitchell (1992, 1993, 1998). The Barbieri (1996) dataset contains bilateral trade for around sixty countries during the period 1870–1947. Data here typically measure bilateral trade between countries a and b by summing imports into a from b and into b from a. We augment this with data from Mitchell (1992,1993,1998) to fill in some of the gaps in Barbieri's coverage from 1870 to 1913.

Measures of conflict are compiled using data on militarized interstate disputes collected by the Correlates of War Project (COW) at the University of Michigan. This dataset measures both the incidence and intensity of hostility at the country level. We code our war variable with

[30] One might question the use of conflict measures in the first stage. It should be noted that these measures of conflict are for disruptions confined to particular spots, which will have limited trade disruption between any two countries. Vessels on the other hand can be attracted to such disruptions, and because they are highly mobile can have more influence on commercial flows through the region. Thus we suggest that regional conflict is likely to influence trade only through the indirect channel of attracting naval vessels.

[31] The full spatial matrix for all country-pairs is available upon request.

conflicts of hostility at medium to high levels of intensity (these include blockades, occupations of territory, seizures, clashes, raids, declarations of war, uses of weaponry, and interstate wars).

A number of other standard variables are added to estimate the gravity model; these include real GDP, population, and various country-pair characteristics, such as contiguity, distance, and mutual use of the gold standard. Real GDP and per capita GDP data come predominantly from Maddison (1995,2001), supplemented where necessary by data from Mitchell (1992,1993,1998). Gold standard data comes from both Lopez-Cordova and Meissner (2003) and Meissner (2005). The CIAs World Factbook provides a number of country-specific variables, including longitude and latitude, land area, physically contiguous neighbors and common languages.[32]

Further, we use two alternative estimates of naval power projection, for each estimate captures somewhat different aspects of power. For example, estimates of tonnage capture the capital intensity of deployment and by proxy the extent of naval technology, since the size and displacement of a vessel was highly correlated to its technological sophistication (Bennett 1896, Glaser and Rahman 2014). Personnel measures on the other hand capture the labor-intensive part of naval deployment.

We also perform an alternative 2-stage approach similar to Irwin and Tervio (2002).[33] Here we perform traditional 2SLS by regressing actual naval deployment on estimated naval deployment in the bilateral setting in the first stage. Results on trade effects remain remarkably consistent with this alternative specification.

In terms of functional form, we log all non-binary variables in order to estimate elasticities. All model estimates include bilateral-pair fixed effects and year effects. Bilateral-country fixed effects are particularly important in this context. As usual, they control for fixed factors such as distance between countries and potential cultural or linguistic commonalities that may influence trade. Particular to this study, they also control for the number and type of naval fronts (stations) through which maritime commerce flows. As mentioned earlier, some fronts may be bigger or smaller than others, or more prone to conflict, or more strategically important. These factors

[32]Naturally we only use the time-invariant measures with the pooled, random effects and exporter-importer fixed effects versions of the gravity model.

[33]Their study looks to how trade influences growth. They first estimate bilateral trade between country pairs. Like us, they aggregate these estimates for use in a second-stage regression.

may on average induce greater or lesser naval presence. Bilateral fixed effects allow us to observe the trade effects from changes in naval deployment, given these considerations. For third party trade we alternatively include exporter and importer fixed effects.[34]

4.1 Empirical Findings

Results from these exercises are displayed in tables 5–8. For each naval power (Britain and France) we look at deployment effects on own trade with partner countries (tables 5 and 7). We also look separately at the effect on other countries' (third party) trade (tables 6 and 8).[35]

Tables 5 and 6 display results for the effects of British naval deployment on bilateral trade. Tables 7 and 8 display parallel results for French naval deployment. As we see in all these bilateral fixed-effect gravity model results, the main factor that explains trade is gross GDP; other factors such as bilateral conflict do not appear to matter much for trade during this period. We also use pooled estimates with more time-invariant regressors such as distance, past colonial connections, and so on. Results are not reported but naval effects remain essentially unaltered.

The main result from table 5 is that British naval power tends to bolster its own trade with other nations. Specifically, a one percent rise in naval power in a region is associated with roughly a fifth of a percent higher trade volumes. Further, we suggest that this is a causal relationship, as we also instrument for this naval projection measure, using either our OLS estimates or our SEM estimates in arms race model.

We also find that British naval power damages trade for third parties. Combining these insights lead us to suggest that the Royal Navy was an agent of neo-mercantilism. Power projections strengthen trade ties between the British and other nations, but these siphon away trade between other nations. There may be other factors at work of course — perhaps these vessels "exported" localized conflicts to bigger theatres; perhaps naval ships signalled to merchants that problems may be afoot and to keep wide berth; perhaps they induced the fear of possible inspec-

[34] Anderson and van Wincoop (2003) suggest that multilateral resistance terms may be important in gravity models. One approach to address this is to include country-specific dummies (instead of bilateral dummies). An alternative is to include relative shares of world GDP. Neither influence regression results in any meaningful (results available upon request).

[35] We should also mention that we include cross effects of conflict between trading countries and naval power, with no meaningful effects (not reported)

tion/seizure of cargo. We cannot disentangle and distinguish between these possibilities here. What we can claim is that the evidence suggests that the global arms race for naval superiority disrupted the trade of other parties.

We might also ask if our “instruments” for naval power are weak. Given our somewhat non-standard approach, we cannot employ typical tests to detect weak instruments. Yet there are a number of factors to which we can point to counter any such claim. First, Stock et al. (2002) suggest F-tests for the first stage to test for relative strength. For both Britain and France, first-stage F-stats are consistently above critical values for such tests.[36] Second, the authors suggest that for relevant but weak instruments, estimates from instrumental variables are biased towards OLS estimates. But as we can see from tables 5–8, estimates from our two-stage or three-stage approach are consistently further from zero (in absolute terms) than OLS estimates. We also see how results change when we change the specification of the first stage, including fewer “instruments.” Results change very little from this, suggesting we do not face weak instrumentation from the inclusion of multiple variables.

Finally, we also report bootstrapped standard errors for our estimated naval power effects (in brackets). To be sure estimated standard errors rise, considerably in some cases – estimates for British naval power generally become insignificant. However, British estimates are statistically significant even when bootstrapping standard errors when we include exporter-importer fixed effects (reported in Appendix).

What about France? We find remarkably similar effects — French naval power boosted its own trade, but hurt third-party trade. Estimated elasticities are also fairly comparable. Even when using bootstrapped standard errors, results remain statistically significant (at least at the 95 percent level). While it may be unsurprising that France would disrupt commerce, given its *Jeune Ecole* strategy, it is somewhat ironic that Britain’s naval affects are similar, given its purported avowal for commercial and global stability. Thus despite the differences in strategies between the two naval powers, they appear to each support their own trade at the expense of others.

Finally, we might ask how costly these mercantilistic quests for power and profits based

[36]This is also true when we employ the 2SLS approach of Irwin and Tervio (2002).

upon expansion overseas were to global commerce. This is hard to answer; the zero-sum effects suggested here are difficult to fully quantify. But if we believe in the importance of commerce overall, these findings suggest the flexing of nautical muscle may come with some hefty price-tags.

5 Conclusion

Navies exist to provide for the safety, security and prosperity of their *own* countries. In this paper we ask if this comes at the expense of other countries, or if it provides a global infrastructure of stability for the world's enjoyment? Our analysis suggests that the first global arms race contributed to personal gains but global losses in terms of international commerce.

This study should spur future research in a number of areas. One line of research would be to develop theories on how arms races can create positive or negative external effects on commercial activity. Another more empirical line of inquiry would be to link specific merchant voyages with potential interactions with naval powers, either historically or contemporaneously. Such research can further help scholars understand the various ways international power and commerce can influence each other.

Today over 90 percent of the world's trade is carried by sea. This work should provide a cautionary tale — current U.S. and Chinese naval exercises may have profound commercial effects, given the sheer volume of tonnage passing through the South China Sea (Kaplan 2014). How factors such as the recent U.S. naval "pivot" towards the Pacific might influence regional trade among APEC nations, for example, are important considerations for both economics and international relations. History gives us some factors to consider.

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Appendix Tables

Table 1: Summary of Naval Statistics

	Naval Power			
	Britain	France	United States	Germany
coverage	1878 – 1914	1872 – 1913	1870 – 1912	1890 – 1910 (with gaps)
total vessels (includes inactive vessels)	552	724	464	238
average displacement per ship (tons)	3657.1	3191.0	3206.6	5129.7
average no. of officers per ship	3.1	5.2	1.2	4.4
average no. of engineers per ship	1.5	1.4	0.3	2.2
average no. of guns per ship	6.9	6.0	-	-
average horsepower per ship	12635	4860	-	7683

Table 2: Estimating Aggregative Tonnage of British Vessels Deployed

Variable	(1) OLS	(2) OLS	(3) OLS	(4) SEM	(5) SEM	(6) SEM
naval expenditures	6945.6***	3180.6***	3045.8***	4943.8***	910.0***	493.4**
	(1502.9)	(576.2)	(679.3)	(1169.5)	(371.0)	(241.9)
distance	8.4***	4.0***	2.9*	6.1***	0.89	-0.31
	(2.8)	(1.5)	(1.6)	(2.5)	(1.25)	(0.87)
exp*distance	-0.63***	-0.25***	-0.26***	-0.43***	-0.09**	-0.02
	(0.14)	(0.06)	(0.07)	(0.13)	(0.04)	(0.03)
hostility with U.K. (indicator, lagged)	40228.4***	-2081.8	1894.7	18645.4	-2907.9	-
	(16005.8)	(12929.4)	(11867.5)	(18130.6)	(6309.2)	
hostility days (lagged)	-281.6***	-79.1	-94.4	-177.3*	-11.4	-
	(10.3.2)	(73.1)	(79.6)	(101.8)	(35.7)	
number of U.K. allies (lagged)	20911.6**	12691.5*	4716.3	16547.5***	68.37.8	-
	(10408.9)	(6735.3)	(6579.2)	(6756.7)	(4456.3)	
French navy deployment (tonnage)	-	1.6***	1.5***	0.88**	1.9***	-
		(0.18)	(0.20)	(0.44)	(0.12)	
U.S. navy deployment (tonnage)	-	-	0.33***	-	0.60***	0.90***
			(0.12)		(0.12)	(0.13)
French or German navy deployment (tonnage)	-	-	-	-	-	2.1***
						(0.11)
R-squared	0.39	0.77	0.72	-	-	-
F-stat	34.4	39.8	34.1	-	-	-
Chi-squared	-	-	-	353.8***	642.2***	652.7***
Observations	288	288	272	288	272	272

Notes: Dependent variable is gross tonnage of British vessels deployed in a region.
OLS — Ordinary least squares. SEM — Simultaneous equations model.
Naval expenditures measured in thousands of 1913 British pounds. *Distance* measured in kilometers.
French or German navy deployment variable measures French deployment for 1872–1900 and Germany for 1902–1911.
Standard errors clustered by country reported in parentheses with *10%, **5% and ***1%.

Table 3: Estimating Aggregative Tonnage of French Vessels Deployed

Variable	(1) OLS	(2) OLS	(3) OLS	(4) SEM	(5) SEM
naval expenditures	5621.9***	492.3	415.7	1649.8*	607.6
	(1838.3)	(817.2)	(1047.5)	(1002.6)	(560.5)
distance	3.4	0.69	-0.22	1.4	-0.37
	(2.1)	(1.2)	(1.4)	(1.6)	(1.0)
exp*distance	-0.58***	-0.12	-0.04	-0.23*	0.07
	(0.19)	(0.09)	(0.12)	(0.13)	(0.08)
hostility with France (indicator, lagged)	7404.8	-373.7	4373.8	1020.7	1453.2
	(11351.5)	(8650.9)	(8028.4)	(6400.4)	(3461.2)
hostility days (lagged)	32.6	66.7	40.4	58.4	8.1
	(48.8)	(48.3)	(42.9)	(37.9)	(19.2)
number of French allies (lagged)	7484.0	-11590.3	36.0	-5597.6	-1935.5
	(5974.9)	(7766.7)	(8956.3)	(5600.6)	(2587.1)
British navy deployment (tonnage)	-	0.39***	0.34***	0.30***	0.47***
		(0.04)	(0.05)	(0.07)	(0.03)
U.S. navy deployment (tonnage)	-	-	-0.23***	-	-0.31***
			(0.05)		(0.05)
R-squared	0.27	0.73	0.68	-	-
F-stat	16.5	26.8	22.8	-	-
Chi-squared	-	-	-	288.6***	417.8***
Observations	336	288	272	288	272

Notes: Dependent variable is gross tonnage of French vessels deployed in a region.
OLS — Ordinary least squares. SEM — Simultaneous equations model.
Naval expenditures measured in thousands of 1913 British pounds. *Distance* measured in kilometers.
Standard errors clustered by country reported in parentheses with *10%, **5% and ***1%.

Table 4: Estimating Aggregative Tonnage of U.S. Vessels Deployed

Variable	(1) OLS	(2) OLS	(3) SEM	(4) SEM
naval expenditures	5133.4***	6175.4***	4610.5***	2549.5***
	(1317.3)	(1479.3)	(778.8)	(801.1)
distance	2.9***	3.6***	2.5	1.1
	(1.2)	(1.4)	(1.6)	(1.4)
exp*distance	-0.74***	-0.87***	-0.72***	-0.44***
	(0.19)	(0.21)	(0.13)	(0.11)
hostility with U.S. (indicator, lagged)	27076.1**	25596.2*	13451.8*	-
	(12817.3)	(14293.7)	(7167.0)	
hostility days (lagged)	-42.7	-55.9	-70.1*	-
	(66.8)	(68.0)	(42.1)	
number of U.S. allies (lagged)	-5863.0	-16263.7	-4785.8	-
	(19806.6)	(19872.9)	(13570.6)	
British navy deployment (tonnage)	-	0.14*	0.52***	0.65***
		(0.08)	(0.08)	(0.11)
French navy deployment (tonnage)	-	-0.61***	-1.3***	-
		(0.17)	(0.19)	
French or German navy deployment (tonnage)	-	-	-	-1.6***
				(0.22)
R-squared	0.33	0.47	-	-
F-stat	11.6	9.12	-	-
Chi-squared	-	-	198.1***	163.7***
Observations	328	272	272	272

Notes: Dependent variable is gross tonnage of U.S. vessels deployed in a region.
OLS — Ordinary least squares. SEM — Simultaneous equations model.
Naval expenditures measured in thousands of 1913 British pounds.
Distance measured in kilometers.
French or German navy deployment variable measures French deployment for 1872–1900 and Germany for 1902–1911.
Standard errors clustered by country reported in parentheses
with *10%, **5% and ***1%.

Table 5: Effects of British Naval Deployment on British Bilateral Trade

Variable	(1)	(2)	(3)	(4)	(5)	(6)
$\ln(Y_i Y_j)$	0.44***	0.29***	0.26***	0.44***	0.34***	0.34***
	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)
$\ln(y_i y_j)$	0.43***	0.61***	0.65***	0.43***	0.55***	0.55***
	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)
Country-pair war	-0.07	-0.08	-0.08	-0.06	-0.08	-0.08
	(0.07)	(0.06)	(0.07)	(0.07)	(0.07)	(0.07)
Regional war	0.05	0.04	0.04	0.04	0.05	0.05
	(0.03)	(0.03)	(0.04)	(0.03)	(0.03)	(0.05)
Both countries on gold standard	0.03	-0.02	-0.02	0.03	-0.03	-0.02
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
ln(Gross tonnage of British vessels)	0.01	0.19***	0.24***	-	-	-
	(0.02)	(0.03)	(0.04)			
		[0.13]	[0.17]			
ln(Number of British naval officers)	-	-	-	-0.008	0.25***	0.27***
				(0.02)	(0.04)	(0.05)
					[0.22]	[0.25]
Uninstrumented	yes	no	no	yes	no	no
2-Stage Model	no	yes	no	no	yes	no
3-Stage Model	no	no	yes	no	no	yes
R-squared	0.54	0.29	0.20	0.52	0.46	0.44
Chi-square (Hausman test)	-	81.4***	83.3***	-	70.6***	69.1***
Observations	1306	1284	1284	1306	1284	1284
Number of country-pairs	42	42	42	42	42	42

Notes: Dependent variable is logged bilateral trade between two countries.
Y_i denotes the GDP of country i; y_i denotes the GDP per capita of country i.
2-Stage Model is where OLS estimates from first stage are used as naval power measures.
3-Stage Model is where SEM estimates from first stage are used as naval power measures.
Hausman test statistic is on test for hypothesis that estimated coefficients on actual and estimated naval powers are not systematically different.
All specifications include bi-lateral country and time fixed effects.
Standard errors clustered by country-pair reported in parentheses with *10%, **5% and ***1%.
Bootstrapped standard errors reported in brackets.

Table 6: Effects of British Naval Deployment on Third-Party Trade

Variable	(1)	(2)	(3)	(4)	(5)	(6)
$\ln(Y_i Y_j)$	0.43***	0.38***	0.38***	0.43***	0.38***	0.38***
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
$\ln(y_i y_j)$	-0.03	0.03	0.03	-0.01	0.03	
	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)
Country-pair war	-0.016	-0.01	-0.01	-0.02	-0.01	-0.01
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
Regional war	-0.03	-0.02	-0.02	-0.03	-0.02	-0.02
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
One country on gold standard	-0.03	-0.04	-0.03	-0.04	-0.05	-0.05
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Both countries on gold standard	0.13***	0.12**	0.12**	0.12**	0.11**	0.11**
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
ln(Gross tonnage of British vessels)	0.02	-0.03***	-0.03***	-	-	-
	(0.015)	(0.01)	(0.01)			
		[0.024]	[0.03]			
ln(Number of British naval officers)	-	-	-	-0.01	-0.12***	-0.14**
				(0.02)	(0.03)	(0.04)
					[0.11]	[0.11]
Uninstrumented	yes	no	no	yes	no	no
2-Stage Model	no	yes	no	no	yes	no
3-Stage Model	no	no	yes	no	no	yes
R-squared	0.22	0.26	0.26	0.24	0.29	0.27
Chi-square (Hausman test)	-	45.1***	43.3***	-	51.3***	51.7***
Observations	5826	5754	5754	5826	5754	5754
Number of country-pairs	310	310	310	310	310	310

Notes: Dependent variable is logged bilateral trade between two non-U.K countries.
Y_i denotes the GDP of country i; y_i denotes the GDP per capita of country i.
2-Stage Model is where OLS estimates from first stage are used as naval power measures.
3-Stage Model is where SEM estimates from first stage are used as naval power measures.
Hausman test statistic is on test for hypothesis that estimated coefficients on actual and estimated naval powers are not systematically different.
All specifications include bi-lateral country and time fixed effects.
Standard errors clustered by country-pair reported in parentheses with *10%, **5% and ***1%.
Bootstrapped standard errors reported in brackets.

Table 7: Effects of French Naval Deployment on French Bilateral Trade

Variable	(1)	(2)	(3)	(4)	(5)	(6)
$\ln(Y_i Y_j)$	0.51***	0.49***	0.22	0.56***	0.46***	0.19
	(0.13)	(0.13)	(0.15)	(0.13)	(0.13)	(0.15)
$\ln(y_i y_j)$	-0.14	-0.09	0.45*	-0.17	-0.03	0.47*
	(0.21)	(0.21)	(0.25)	(0.20)	(0.21)	(0.25)
Country-pair war	-0.02	-0.02	-0.03	-0.03	-0.03	-0.04
	(0.12)	(0.12)	(0.11)	(0.16)	(0.11)	(0.11)
Regional war	-0.11*	-0.10	-0.15**	-0.12**	-0.13**	-0.14**
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
One country on gold standard	-0.18**	-0.10	-0.07	-0.18**	-0.07	-0.07
	(0.09)	(0.09)	(0.20)	(0.09)	(0.09)	(0.20)
Both countries on gold standard	-0.23**	-0.17	-0.17	-0.24**	-0.12	-0.16
	(0.11)	(0.12)	(0.21)	(0.12)	(0.12)	(0.21)
ln(Gross tonnage of French vessels)	0.001	0.03***	0.24***	-	-	-
	(0.01)	(0.01)	(0.04)			
		[0.01]	[0.10]			
ln(Number of French naval officers)	-	-	-	0.05**	0.27***	0.39***
				(0.02)	(0.05)	(0.06)
					[0.12]	[0.16]
Uninstrumented	yes	no	no	yes	no	no
2-Stage Model	no	yes	no	no	yes	no
3-Stage Model	no	no	yes	no	no	yes
R-squared	0.44	0.42	0.28	0.41	0.22	0.29
Chi-square (Hausman test)	-	7.6**	108.4***	-	18.4**	111.1***
Observations	955	955	861	955	955	861
Number of country-pairs	32	32	32	32	32	32

Notes: Dependent variable is logged bilateral trade between two countries.
Y_i denotes the GDP of country i; y_i denotes the GDP per capita of country i.
2-Stage Model is where OLS estimates from first stage are used as naval power measures.
3-Stage Model is where SEM estimates from first stage are used as naval power measures.
Hausman test statistic is on test for hypothesis that estimated coefficients on actual and estimated naval powers are not systematically different.
All specifications include bi-lateral country and time fixed effects.
Standard errors clustered by country-pair reported in parentheses with *10%, **5% and ***1%
Bootstrapped standard errors reported in brackets.

Table 8: Effects of French Naval Deployment on Third-Party Trade

Variable	(1)	(2)	(3)	(4)	(5)	(6)
$\ln(Y_iY_j)$	0.18***	0.17***	0.06	0.18***	0.17***	0.05
	(0.06)	(0.06)	(0.07)	(0.06)	(0.06)	(0.07)
$\ln(y_iy_j)$	0.53***	0.51***	0.63***	0.53***	0.52***	0.64***
	(0.11)	(0.11)	(0.12)	(0.11)	(0.11)	(0.12)
Country-pair war	-0.06	-0.06	-0.05	-0.06	-0.06	-0.04
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Regional war	0.002	-0.0003	0.009	0.002	0.009	0.02
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
One country on gold standard	0.02	0.005	-0.07	0.02	0.002	-0.07*
	(0.03)	(0.03)	(0.04)	(0.03)	(0.03)	(0.04)
Both countries on gold standard	0.21***	0.19***	0.10**	0.21***	0.19***	0.10**
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)
ln(Gross tonnage of French vessels)	-0.003	-0.02***	-0.03***	-	-	-
	(0.005)	(0.005)	(0.006)			
		[0.009]	[0.01]			
ln(Number of French naval officers)	-	-	-	-0.007	-0.10***	-0.12***
				(0.01)	(0.02)	(0.02)
					[0.03]	[0.04]
Uninstrumented	yes	no	no	yes	no	no
2-Stage Model	no	yes	no	no	yes	no
3-Stage Model	no	no	yes	no	no	yes
R-squared	0.29	0.29	0.19	0.29	0.29	0.19
Chi-square (Hausman test)	-	15.5**	193.6***	-	25.3**	214.8***
Observations	6858	6858	6264	6858	6858	6264
Number of country-pairs	320	320	320	320	320	320

Notes: Dependent variable is logged bilateral trade between two non-France countries.
Y_i denotes the GDP of country i; y_i denotes the GDP per capita of country i.
2-Stage Model is where OLS estimates from first stage are used as naval power measures.
3-Stage Model is where SEM estimates from first stage are used as naval power measures.
Hausman test statistic is on test for hypothesis that estimated coefficients on actual and estimated naval powers are not systematically different.
All specifications include bi-lateral country and time fixed effects.
Standard errors clustered by country-pair reported in parentheses with *10%, **5% and ***1%
Bootstrapped standard errors reported in brackets.

Part A

The following two tables show gravity-model results for third-party trade using importer and exporter fixed effects (instead of bilateral fixed effects). The negative effects on trade from naval power projection remain intact.

Table 9: Effects of English Naval Deployment on Third-Party Trade

Variable	(1)	(2)	(3)	(4)	(5)	(6)
$\ln(Y_iY_j)$	0.41***	0.35***	0.36***	0.40***	0.36***	0.36***
	(0.11)	(0.11)	(0.12)	(0.11)	(0.11)	(0.11)
$\ln(y_iy_j)$	0.01	0.05	0.05	0.05	0.05	0.05
	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)
ln(distance)	-0.26***	-0.26***	-0.26***	-0.22***	-0.21***	-0.21***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Country-pair war	0.39***	0.41***	0.41	0.40***	0.41***	0.41***
	(0.11)	(0.12)	(0.12)	(0.11)	(0.12)	(0.12)
Regional war	-0.23***	-0.22***	-0.22***	-0.23***	-0.21***	-0.21***
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
One country on gold standard	-0.010	-0.002	-0.002	-0.02	-0.02	-0.01
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Both countries on gold standard	0.12	0.14*	0.13*	0.10	0.12	0.12
	(0.08)	(0.08)	(0.08)	(0.06)	(0.08)	(0.08)
ln(Gross tonnage of British vessels)	-0.04***	-0.04***	-0.04***	-	-	-
	(0.006)	(0.006)	(0.006)			
		[0.02]	[0.02]			
ln(Number of British naval officers)	-	-	-	-0.11***	-0.12***	-0.12***
				(0.01)	(0.01)	(0.01)
					[0.06]	[0.08]
Uninstrumented	yes	no	no	yes	no	no
2-Stage Model	no	yes	no	no	yes	no
3-Stage Model	no	no	yes	no	no	yes
R-squared	0.52	0.50	0.51	0.52	0.51	0.51
Chi-square (Hausman test)	-	37.9***	34.2***	-	34.5***	34.2***
Observations	5826	5754	5754	5826	5754	5754

Notes: Dependent variable is logged bilateral trade between two countries.
Y_i denotes the GDP of country i; y_i denotes the GDP per capita of country i.
2-Stage Model is where OLS estimates from first stage are used as naval power measures.
3-Stage Model is where SEM estimates from first stage are used as naval power measures.
Hausman test statistic is on test for hypothesis that estimated coefficients on actual and estimated naval powers are not systematically different.
All specifications include importer, exporter and time fixed effects.
Standard errors clustered by country-pair reported in parentheses with *10%, **5% and ***1%
Bootstrapped standard errors reported in brackets.

Table 10: Effects of French Naval Deployment on Third-Party Trade

Variable	(1)	(2)	(3)	(4)	(5)	(6)
$\ln(Y_iY_j)$	0.21**	0.24***	0.11	0.15	0.24***	0.11
	(0.10)	(0.10)	(0.12)	(0.10)	(0.10)	(0.12)
$\ln(y_iy_j)$	0.46***	0.35**	0.51***	0.55***	0.38**	0.53***
	(0.17)	(0.17)	(0.20)	(0.18)	(0.17)	(0.20)
ln(distance)	-0.11***	-0.05	-0.01	-0.07**	-0.005	0.017
	(0.03)	(0.03)	(0.04)	(0.03)	(0.03)	(0.04)
Country-pair war	0.35***	0.32***	0.33***	0.35***	0.32***	0.34***
	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)
Regional war	-0.17***	-0.18***	-0.15***	-0.15***	-0.16***	-0.13***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
One country on gold standard	-0.02	-0.05	-0.10*	-0.03	-0.06	-0.10*
	(0.05)	(0.05)	(0.06)	(0.05)	(0.05)	(0.053)
Both countries on gold standard	0.23***	0.21***	0.07	0.22***	0.21***	0.10
	(0.07)	(0.07)	(0.08)	(0.07)	(0.07)	(0.08)
ln(Gross tonnage of French vessels)	-0.04***	-0.04***	-0.05***	-	-	-
	(0.005)	(0.005)	(0.005)			
		[0.017]	[0.02]			
ln(Number of French naval officers)	-	-	-	-0.11***	-0.13***	-0.14***
				(0.01)	(0.01)	(0.01)
					[0.04]	[0.05]
Uninstrumented	yes	no	no	yes	no	no
2-Stage Model	no	yes	no	no	yes	no
3-Stage Model	no	no	yes	no	no	yes
R-squared	0.44	0.43	0.38	0.41	0.44	0.38
Chi-square (Hausman test)	-	13.4**	287.2***	-	16.9**	286.1***
Observations	6858	6858	6264	6858	6858	6264

Notes: Dependent variable is logged bilateral trade between two non-France countries.
Y_i denotes the GDP of country i; y_i denotes the GDP per capita of country i.
2-Stage Model is where OLS estimates from first stage are used as naval power measures.
3-Stage Model is where SEM estimates from first stage are used as naval power measures.
Hausman test statistic is on test for hypothesis that estimated coefficients on actual and estimated naval powers are not systematically different.
All specifications include importer, exporter and time fixed effects.
Standard errors clustered by country-pair reported in parentheses with *10%, **5% and ***1%
Bootstrapped standard errors reported in brackets.

Part B

The following table shows gravity-model results when measuring naval power by weighting each ship's tonnage by a measure of its technology, either horsepower or speed. Estimates are difficult to quantitatively interpret, but they simply show that incorporating a measure of naval "technology" does nothing to the overall conclusions.

The precise calculation is $ln\left(\sum_i^N (tonnage_i \cdot horsepower_i)/avg.horsepower\right)$ for the power projection of N ships in a region. $avg.horsepower$ is simply the average horsepower of all active vessels in that region. Comparable measures for speed-weighted displacement are also calculated. Alternative measures for technology weighting does not alter any qualitative conclusions.

Table 9: Effects of British "Technologically-Weighted" Naval Tonnage Deployed (instrumented) on Third-Party Trade

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ln(Gross tonnage of British vessels	0.01***	0.02***	-	-	-0.003*	-0.008	-	-
- horsepower-weighted)	(0.002)	(0.006)			(0.002)	(0.006)		
	[0.003]	[0.015]			[0.005]	[0.02]		
ln(Gross tonnage of British vessels	-	-	0.015***	0.015***	-	-	-0.02***	-0.015***
- speed-weighted)			(0.004)	(0.004)			(0.004)	(0.004)
			[0.007]	[0.008]			[0.005]	[0.008]
British trade	yes	yes	yes	yes	no	no	no	no
Non-British trade	no	no	no	no	yes	yes	yes	yes
2-Stage Model	no	yes	no	yes	no	yes	no	yes
3-Stage Model	yes	no	yes	no	yes	no	yes	no
R-squared	0.48	0.49	0.47	0.48	0.19	0.20	0.20	0.20
Observations	1494	1465	1494	1465	6413	6348	6413	6348
Number of country-pairs	42	42	42	42	310	310	310	310

3-Stage Model is where SEM estimates from first stage are used as naval power measures.
Other independent variable coefficient estimates not reported.
All specifications include bi-lateral country and time fixed effects.
Standard errors clustered by country reported in parentheses
with *10%, **5% and ***1%.
Bootstrapped standard errors reported in brackets.

Figures

Figure 1: Total Number of Active Vessels Across All Waters

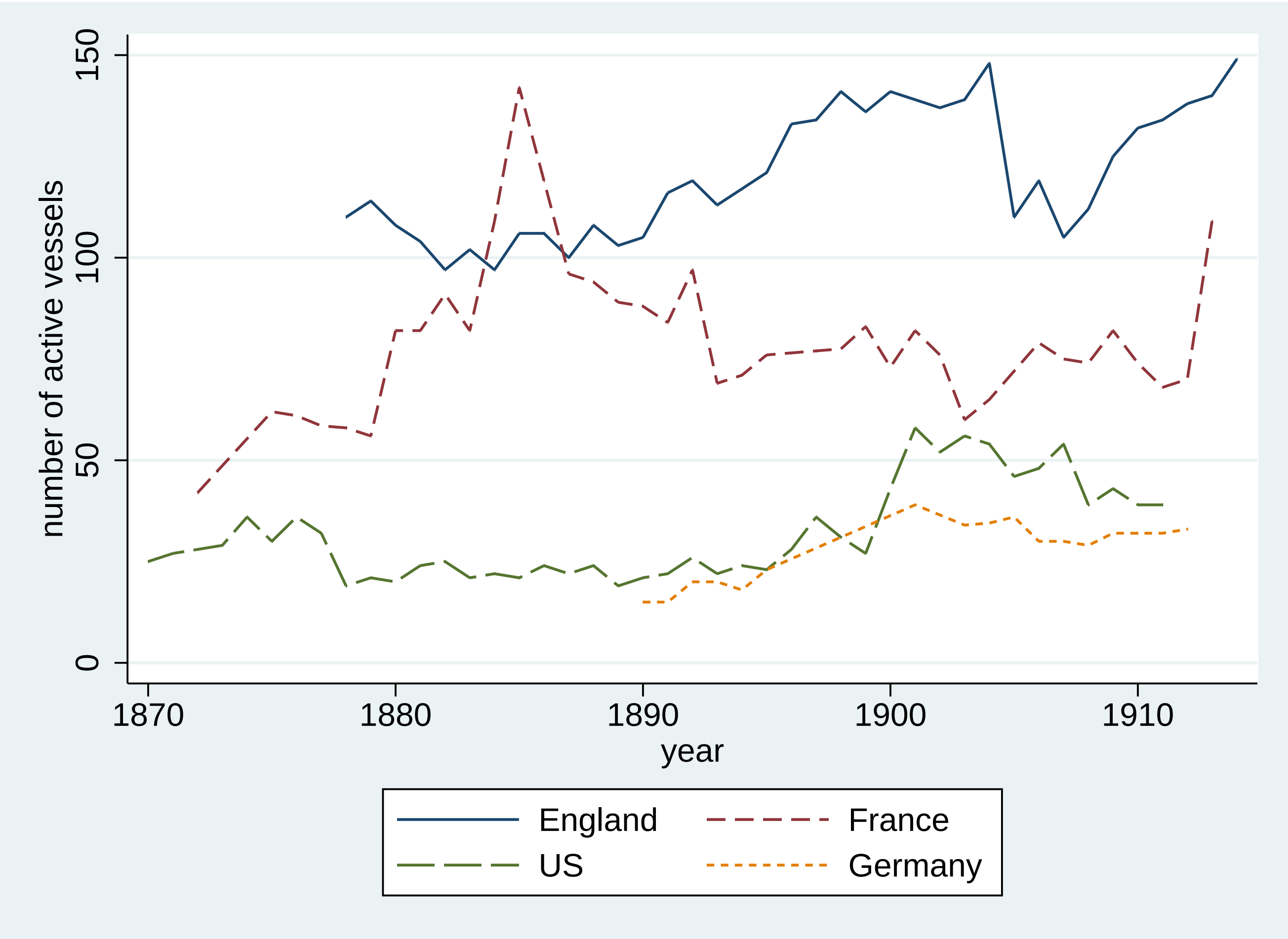

Figure 2: Total Displacement of Active Vessels Across All Waters

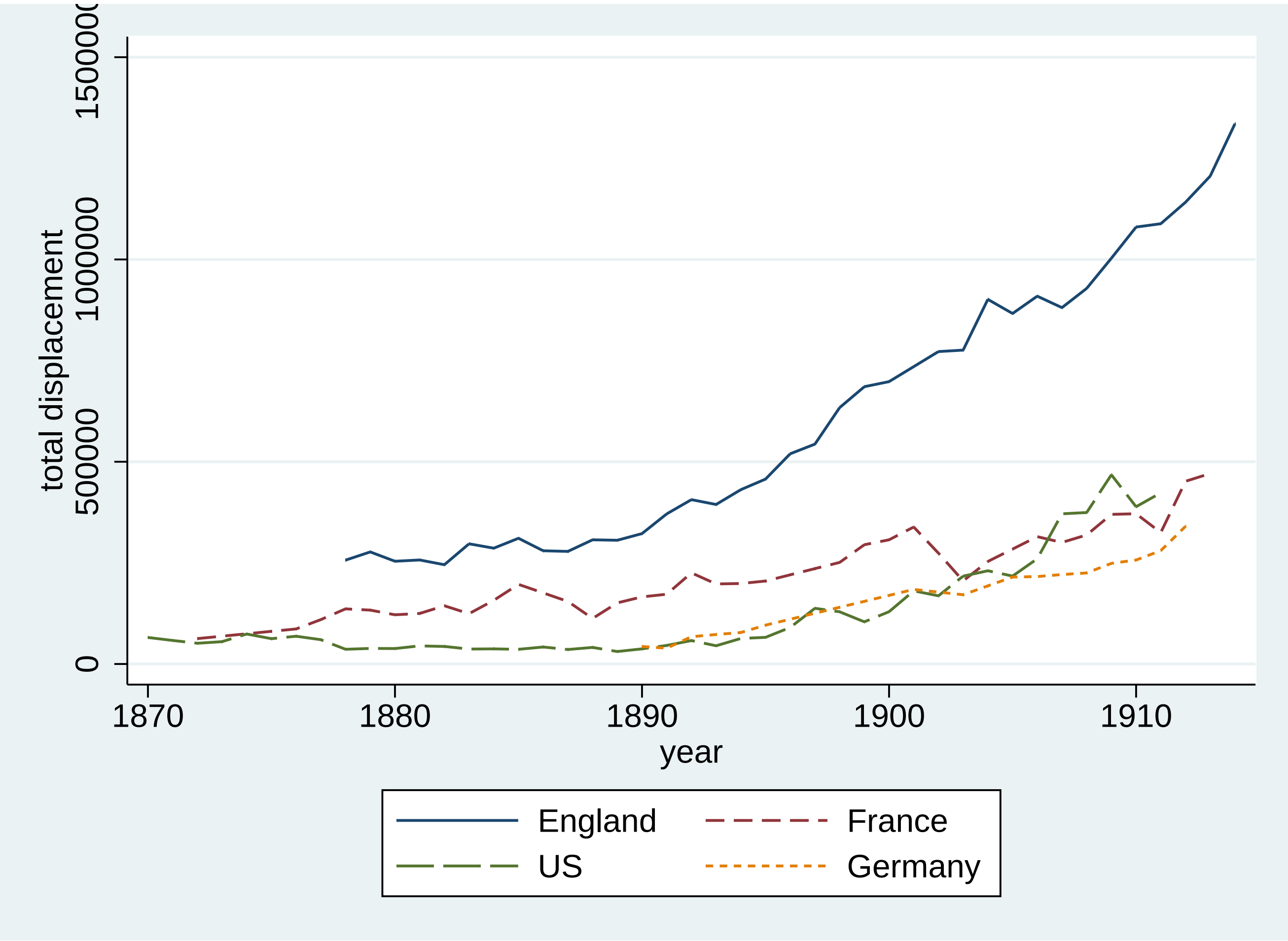

Figure 3: Number of Active British Vessels by Station

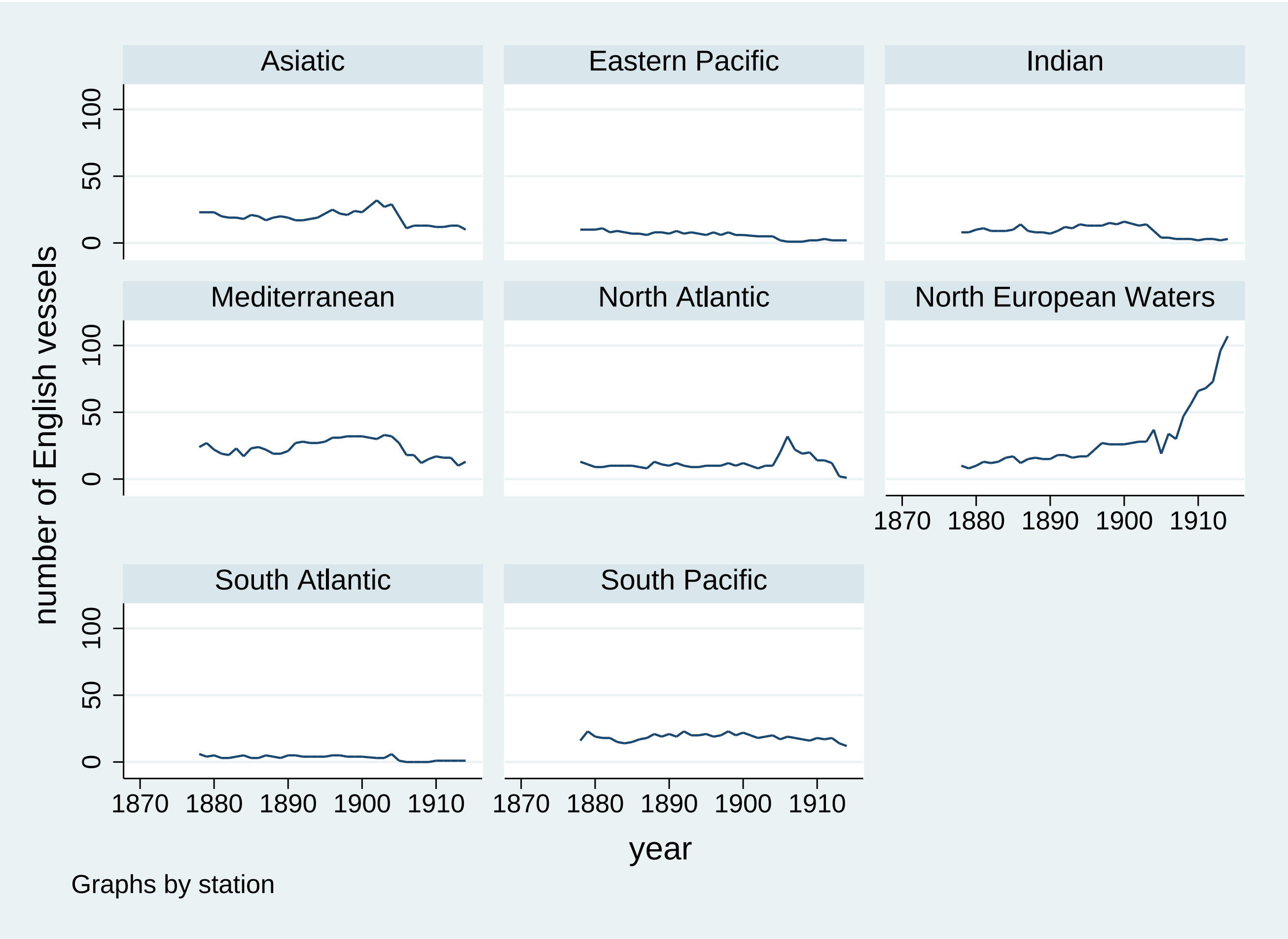

Figure 4: Number of Active French Vessels by Station

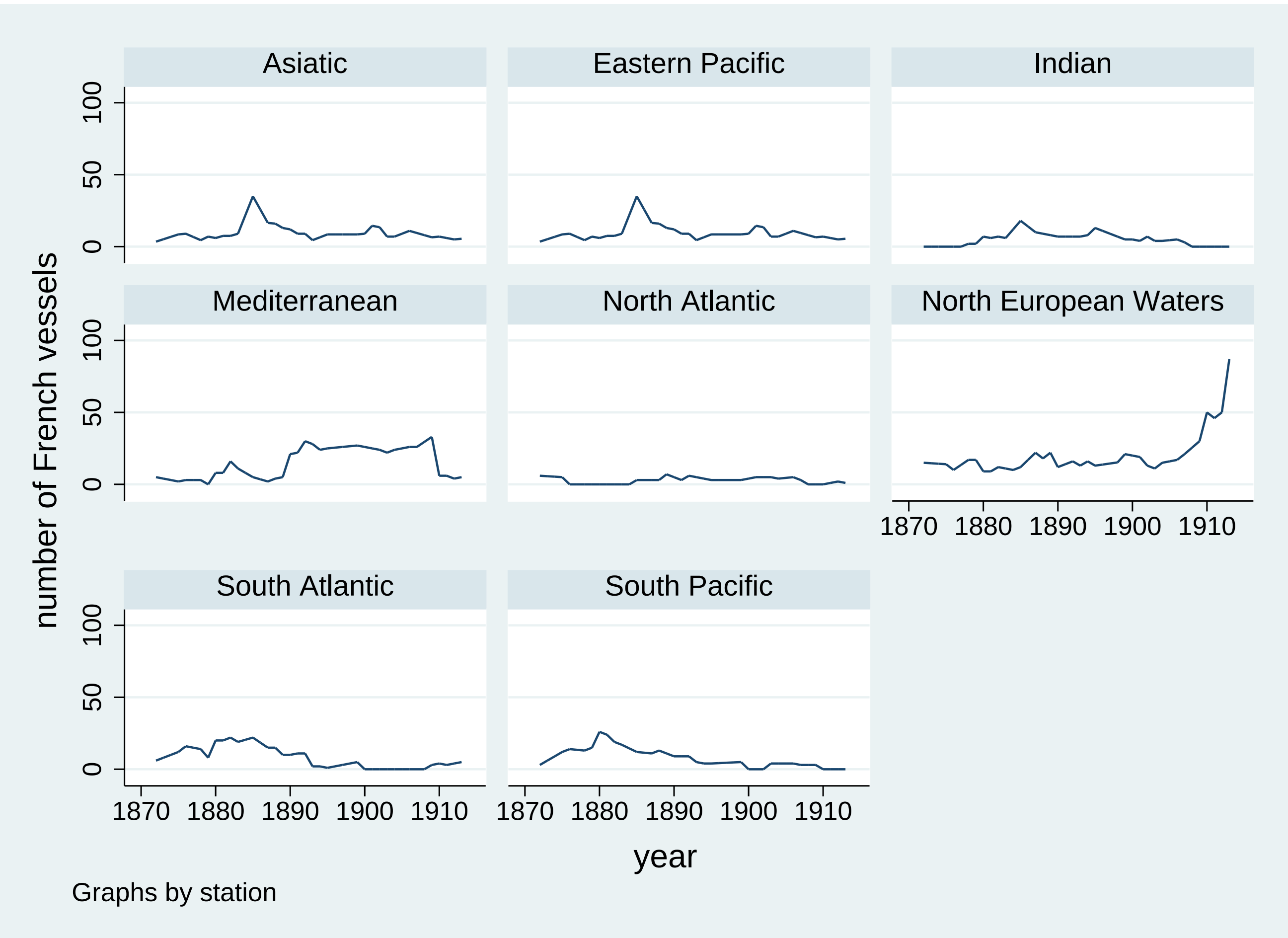

Figure 5: Number of Active American Vessels by Station

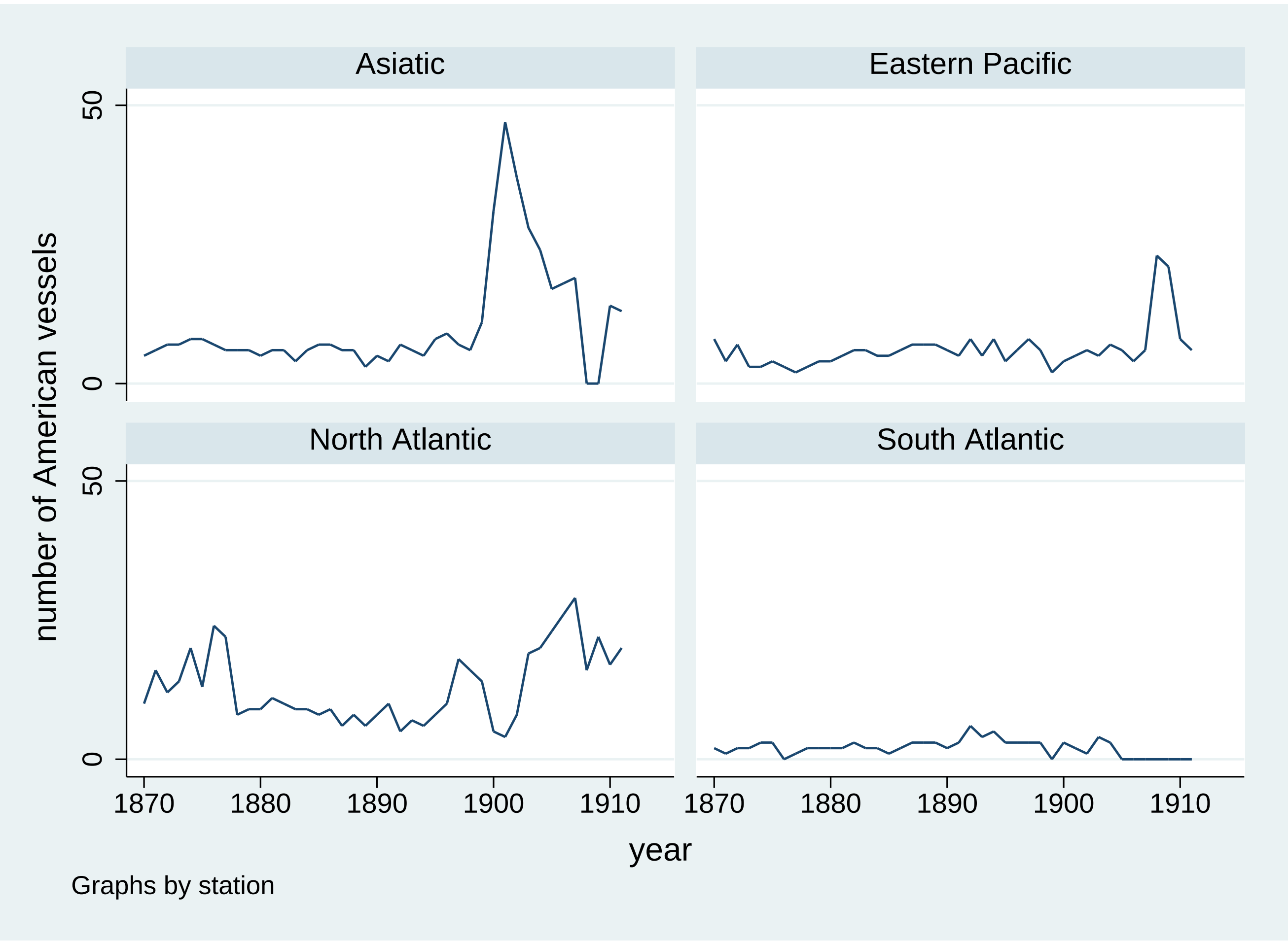

Figure 6: Number of Active German Vessels by Station